2009

PHYSICS

(Honours)

FIFTH PAPER (Phys–211)

(Thermal and Statistical Physics)

Full Marks : 60

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer *any* five questions

1. *(a)* Define normal distribution. Which physical conditions lead to this distribution? Discuss its properties. 2+2+3=7

(b) Explain the basic principles of the kinetic theory of gases. Give kinetic interpretation of temperature. 3+2=5

2. *(a)* Show that the mean free path of a gas molecule is inversely proportional to the pressure. 3

(b) Derive an expression for thermal conductivity of a gas on the basis of kinetic theory of gases. Show that coefficient of thermal conductivity of hydrogen should be largest among all diatomic molecules. 5+4=9

3. (a) State first law of thermodynamics. Give its physical significance. What are the limitations of the first law? 2+2+2=6

(b) State and prove Carnot's theorem. 2+4=6

4. (a) Prove the following thermodynamic relations

(i) $\left(\frac{\partial S}{\partial P}\right)_T = -\left(\frac{\partial V}{\partial T}\right)_P$

(ii) $T\,dS = C_P\,dT - T\left(\frac{\partial V}{\partial T}\right)_P dP$

where the symbols have their usual meanings. 4×2=8

(b) Define four thermodynamic potentials U, F, H and G. 4

5. (a) Explain Joule-Thomson effect using the Maxwell's thermodynamic relations. 5

(b) What do you mean by liquefaction of gases? Mention various methods used for liquefaction of gases. Discuss the difficulties encountered in liquefying hydrogen and helium. 1½+1½+4=7

6. (a) Explain the terms macrostate and microstate with the help of an example. 6

(b) Calculate the number of phase cells, $\phi(E)$, in energy range 0 to E for a 1-D harmonic oscillator. 6

7. (a) Deduce the Maxwell-Boltzmann distribution law

$$n_i = g_i \exp(-\alpha - \beta\varepsilon_i)$$

where the symbols have their usual meanings. 8

(b) Calculate the r.m.s. velocity of a molecule of hydrogen at 27 °C. The Boltzmann's constant is $1{\cdot}38 \times 10^{-23}$ J/deg and Avogadro's number is $6{\cdot}02 \times 10^{23}$/mole. 4

8. (a) What is meant by indistinguishability of particles? What role it plays in quantum statistics? What are its consequences? 2+2+4=8

(b) State Stefan-Boltzmann law of heat radiation. Two large closely spaced concentric spheres (both are blackbody radiators) are maintained at temperatures 400 K and 600 K, respectively. The space in between the two spheres is evacuated. Calculate net rate of energy transfer between the two spheres. 2+2=4

[$\sigma = 5{\cdot}672 \times 10^{-8}$ MKS units]

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